A GUIDE FOR PRECISE MANGO CULTIVATION 2020

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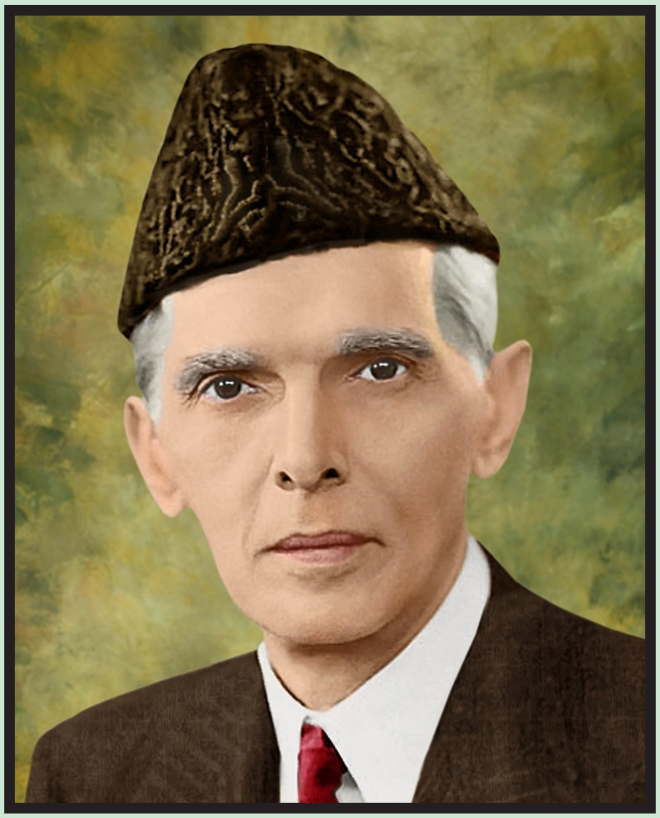
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MANGO RESEARCH INSTITUTE,
OLD SHUJABAD ROAD MULTAN

The Legend

Quaid-e-Azam Muhammad Ali Jinnah (1876-1948)



Quaid-e-Azam Muhammad Ali Jinnah the founder of Pakistan was born in Karachi on December 25th, 1876. He got his early education at Karachi and at the age of 16 he went to England for further studies. in 1896, Jinnah qualified for the Bar and in 1897 was called to the Bar. It was his struggle that despite stiff opposition from the Hindu Congress and the British Government, Muslims of Sub continent managed to get their own home land on August 14, 1947. Jinnah was a man of principles. He was probably the only person among all the big leaders of the worlds, who never went to jail. he was the first Governer General of Pakistan.



Message

We produce about 1700 thousand tons of mango from orchards spread over thousands of acres land mainly in Southern Sindh and Southern Punjab. Realizing the above state of affair and in line with the Government policy to accord priority to the agriculture sector, this public organization has taken some special measures to address the needs of the mango growers. Coinciding with the determination, researchers especially from Mango Research Institute, Multan have been provided an opportunity to write on different topics of great significance in mango cultivation. Surely, mango growers and other stake holders of the industry would benefit from the deliberations immensely.

(Dr. Abid Muhammad)
Director General Agriculture (Research)
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Message

No doubt, the mangoes grown in Pakistan are superior. The demand for the quality produce is on increase within the country and abroad. In Pakistan room for improvement in precise mango cultivation exists. To compete in the world markets there is need to present our produce in accordance with international standards and procedures. Tendency of low density plantation, alternate bearing and incidence of some new insect pests and diseases are yield and quality lowers factors, which are still awaiting comprehensive solutions and need more research. Up to date research efforts with the findings were demanded to write and compile in English for the mango industry stake holders, so that, these could be easily rectified by the foreign experts as well. This task has been completed by the researchers of Mango Research Institute, Multan under my supervision. The revised edition of this book being published contains useful information on the important aspects of mango cultivation, post-harvest handling and export. It is expected that the reader would find the information of interest as some new aspects in mango cultivation have been added. I am also very grateful to Nestle Chaunsa Project for the collaboration in this regard.

(Dr. Hameed Ullah)
Director
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CONTENTS

S.#	Title	Page No.
1	King of Fruits “Mango”	
2	Mango Varieties	
3	Soil and Climate	
4	Mango Propagation	
5	Establishment of Mango Orchard	
6	Care of Orchard After Plantation	
7	Irrigation	
8	Nutrition	
9	Canopy Management	
10	Weed Management	
11	Physiological Disorders	
12	Environmental Disorders	
13	Environment and Mango Crop Pathway	
14	Mango Diseases and their Management	
15	Insect Pest and their Management	
16	Harvesting	
17	Post Harvest Disorders	
18	Export	
19	Key Management Points According to Growth Stages of Mango	
20	Cultivation of mango in small tree system (STS)	
21	Directory	

1. King of Fruits “Mango”

King of fruits “Mango” is one of the most popular and best fruits worldwide. It is grown in Punjab and Sindh provinces of Pakistan and is available in abundance from May to September. The Punjab contributes 65% in area and 77% in overall production of the country. The fruit is variable in size and color and may be yellow, orange, red or green,when ripe, depending upon the variety. Pakistani mangoes are mostly yellow in color when full ripe, have strong aroma and sweet in taste.

Ripe fruits are mainly eaten fresh, but are also used in preparing squash, Jam, other preserves and sometimes canned. Young mangoes are used in making mango chutneys and pickles etc. The export varies from year to year and its volume fluctuates 4-7% of the total produce.

Sindhri, Chaunsa (S.B) and Chaunsa (White) are the major exportable varieties of Pakistan. Pakistan exports mango to over 20 countries while Iran, Netherland, UK and Middle East are major mango consumers.

Multan, Rahim Yar Khan, Khanewal and Muzaffargarh are the major mango growing districts of Punjab. Mango in these districts and surroundings makes a largest cluster of the country and major zone of the mango activity.

Amongst Pakistani mangoes, Multani mangoes have very much importance. Multan is an historical city known for its mangoes all over the world. Its delicious mangoes are equally liked in Pakistan and in the rest of the world. Mango is the best gift from Multan.

The average productivity of mango is almost 11 ton/ha while the potential of Pakistani mango varieties is 25 ton/ha. This low productivity may be attributed to many reasons.

1.1 Reasons for low productivity in mango

There are several reasons that can be attributed for low productivity but among them, the major causes are given below.

- **Predominant existing orchards are of senile in nature**
  Even now, in many parts of the country, senile unproductive orchards are being maintained. These orchards with unmanageable canopy neither produce fruits nor the quality. Besides, these orchards are acting as sources of pests and diseases.
- **Cultivation of undesirable mango varieties**
  There are more than 100 mango varieties exist in Pakistan. Most of these varieties are happened to either poor yielders or alternate bearers.
- **Long gestation period in mango**
  New plantations are established through mango grafts only. Generally, mango orchards take 4 to 7 years to reach commercial production due to several factors including soil, climatic and cultural methods.

- **Alternate bearing habit of mango**
  Except few varieties most of the choice varieties are either alternate bearers or poor yielders.
- **Dominance of vegetative phase over reproductive phase** Evergreen trees bound to grow continuously due to abundant sunlight and improper irrigation throughout the year.
- **Conventional spacing (wider spacing)**
  raditionally, the mango trees are spaced widely resulting into poor land use efficiency and yield.
- **Pest and disease problems**
  Several pests and diseases are affecting the mango throughout the year. The yield loss due to pest and diseases is accounted to more than 15 to 20 per cent in a normal year and even to the extent of 40 to 60 per cent in severe infections.
- **Physiological disorders associated with mango**
  Spongy tissue and jelly seedare typical examples for physiological disorders in mango which affect both the domestic and international trading. Similarly, fruit drop and alternate bearing, are the other disorders associated with mango cultivation.
- **Mal cultural practices:**
  A good yield in mango farming business can be achieved with the help of good farm management skill, proper care and adoption of good agricultural practices. Mal practices like untimely application of fertilizers, over irrigation, unnecessary sprays of pesticides and intercropping in mango orchards are main mal practices which result in low productivity as well as poor quality mangoes.
- **Rapid Urbanization:**
  Housing schemes have mushroomed in the city over the past few years eating into its once fabled orchards of the king of fruits. In Tehsil Multan about 26% area under mangoes was chewed by new colonies in the last few last few years.
- **Lack of coordination:**
  Lack of coordination and harmonization of working of Research, Academia and Extension Departments have nullified the efforts for betterment in mango yield and prosperity of farmer community.

2. Mango Varieties

2.1 An Ideal Mango Variety

None of the existing commercial varieties of mango could be called an ideal type, as these lack some desirable characters or the others. So, we need a mango variety that could meet the challenge of the present-day requirements to establish a distinct industry.In this connection the following suggestions are made:

- Trees ought to be dwarf so that these could be planted at a close distance of 3-4 m. Only then the desirable sanitary conditions for obtaining optimum crop per unit area can be maintained.
- Fruits of a medium size, 5 in a kg with golden apricot color on ripening could be preferred. Red blush on the cheeks would be a welcome character from the export point. Such fruits must have high pulp: stone ratio, firm and fibreless flesh, uniform consistency of the texture with excellent sugar-acid blend and pleasing aroma.
- The variety ought to yield crop every year.
- It should be highly tolerant to various fungal and bacterial diseases and also to mango malformation.
- Stable pleasant flavor should be characteristic of a variety particularly when it undergoes processing.
- Fruits must have high keeping quality.
- Although at present none of the commercial varieties of mango has all these characteristics combined into one, it would be futile to take up all these objectives at a time in any mango breeding work.
  Therefore these characters are to be incorporated at stages and the variety is to be built up gradually.

2.2 Important Commercial Varieties

There are hundreds of varieties in mango out of which only a few happen to be of commercial importance.

- It must tolerate the prevailing problems of salinity in soil as well as high pH.
  Ideal variety must have better shelf life.

- The variety should tolerate weather extremes as well as well as fit in current climate change events.

- Long expected fruiting age is also a desirable characteristic of an ideal variety.

LANGRA

Time of fruit availability	1st week of June to – 1st week of July
Average size of mature fruit LxBxT	9-11 x 6-8 x 6-7 cm
Average weight per fruit	250 – 350 grams
Fruit shape in cross section	Circular
Color of peel	Sea green
Fruit Skin	Smooth
Pulp Color	Lemon yellow
Total soluble solids	19 – 20° Brix
Acidity	0.18 – 0.19%
Presence of fiber	Medium
Distinguished traits	Excellent flavor, highly accepted by the consumers but shy bearer.



DUSEHRI

Time of fruit availability	1st week of June to – 1st week of July
Average size of mature fruit LxBxT	8-10 x 6-8 x 4-7 cm
Average weight per fruit	220 – 250 grams
Fruit shape in cross section	Narrow elliptic
Color of peel	Lemon yellow
Fruit Skin	Smooth
Pulp Color	Pale yellow
Total soluble solids	25 – 27° Brix
Acidity	0.17 – 0.19%
Presence of fiber	low
Distinguished traits	Excellent variety for national and international marketing. Highly acceptable by the consumers.



ANWAR RETAUL

Time of fruit availability	1st week of June to – 1st week of July
Average size of mature fruit LxBxT	9 x 5-7 x 6-7 cm
Average weight per fruit	200 – 250 grams
Fruit shape in cross section	Broad elliptic
Color of peel	Lemon yellow
Fruit Skin	Smooth
Pulp Color	Cadmium yellow
Total soluble solids	24 – 26° Brix
Acidity	0.17 – 0.18%
Presence of fiber	Very low just beneath the skin
Distinguished traits	Excellent flavor, highly accepted by the consumers but shy bearer.



SINDHRI

Time of fruit availability	1st week of June to – 1st week of July
Average size of mature fruit LxBxT	15-17 x 7-9 x 7-8 cm
Average weight per fruit	750 – 800 grams
Fruit shape in cross section	Broad elliptical
Color of peel	Maize yellow
Fruit Skin	Smooth
Pulp Color	Medium yellow
Total soluble solids	16 – 17° Brix
Acidity	0.18 – 0.22%
Presence of fiber	Absent
Distinguished traits	Excellent flavor, highly accepted by the consumers and has significant volume in export.



S.B CHAUNSA

Time of fruit availability	1st week of July – 1st week of August
Average size of mature fruit LxBxT	11-14 x 6-8 x 6-7cm
Average weight per fruit	250 – 300 grams
Fruit shape in cross section	Broad elliptic
Color of peel	Canary yellow
Fruit Skin	Smooth
Pulp Color	Pale yellow
Total soluble solids	25 – 27° Brix
Acidity	0.17 – 0.18%
Presence of fiber	Medium
Distinguished traits	Excellent flavor, with great export potential and highly accepted in national as well as international markets.



FAJRI

Time of fruit availability	2nd week of August – 2nd week of October
Average size of mature fruit LxBxT	15-17 x7-10 x 7-9 cm
Average weight per fruit	350 – 450 grams
Fruit shape in cross section	Narrow elliptic
Color of peel	Sea green
Fruit Skin	Smooth but bumpy
Pulp Color	Pale yellow
Total soluble solids	20 – 22° Brix
Acidity	0.19 – 0.21%
Presence of fiber	Scanty
Distinguished traits	Excellent flavor, highly accepted by the consumers and has significant volume in export.



KALA CHAUNSA

Time of fruit availability	2nd week of August – 2nd week of October
Average size of mature fruit LxBxT	12-15 x 5-8 x 7-9 cm
Average weight per fruit	250 – 350 grams
Fruit shape in cross section	Ovatish oblong
Color of peel	Yellowish green
Fruit Skin	Smooth
Pulp Color	Lemon yellow
Total soluble solids	23 – 24° Brix
Acidity	0.16 – 0.20%
Presence of fiber	Medium to high
Distinguished traits	Late maturing variety, highly accepted by the local consumers. High yielding culminating better returns for the growers.



Note:
Now this variety is being replaced with some new promising varieties in most of the orchards.

RETAUL (LATE)

Time of fruit availability	2nd week of August – 2nd week of October
Average size of mature fruit LxBxT	8-10 x 6-8 x 6-7 cm
Average weight per fruit	150 – 350 grams
Fruit shape in cross section	Narrow elliptic
Color of peel	Lemon Yellow
Fruit Skin	Smooth
Pulp Color	Lemon yellow
Total soluble solids	18 – 20° Brix
Acidity	0.18 – 0.22%
Presence of fiber	Medium
Distinguished traits	Late maturing variety, highly accepted by the local consumers. High yielding culminating better returns for the growers.



SUFAID CHAUNSA

Time of fruit availability	2nd week of August – 2nd week of October
Average size of mature fruit LxBxT	10-15 x 8-10 x 6-8cm
Average weight per fruit	350 – 450 grams
Fruit shape in cross section	Broad elliptic
Color of peel	Maize yellow
Fruit Skin	Smooth
Pulp Color	Whitish yellow
Total soluble solids	23 – 25° Brix
Acidity	0.18 – 0.19%
Presence of fiber	Medium
Distinguished traits	Excellent variety for national as well as international marketing being exported to different countries. Highly accepted by the mango growers due to medium regular in bearing, late in ripening and earning more income for the growers.



LATE RETAUL

Time of fruit availability

Time of fruit availability	2nd week of August – 2nd week of
Average size of mature fruit LxBxT	October8-10 x 6-8 x 6-7 cm
Average weight per fruit	150-350 grams
Fruit shape in cross section	Oblongish ovate
Color of peelSize of lenticels	Lemon yellow
Fruit skin	Medium
Pulp color	Smooth
Total soluble solids	Lemon yellow
Acidity	18-20 %
Presence of fiber	0.18 - 0.22%
Distinguished trait	Medium



Late maturing variety. Highly accepted by consumers.
High yielding culminating better returns for the growers.
High yielding culmination better
returns for the growers

2.3 New Promising Selections

Rate-e-wala (Azeemo) and Late Sindhri are new promising selections of mango with most of the desirable and some distinguished traits. These new selections are receiving very good response from the high end markets while export and the mango growers are increasing their plantation day by day.

AZEEM CHANUNSA

Time of fruit availability	2nd week of September to -2nd week of October
Average weight per fruit	230-275 g
Total soluble solids (TSS)	23° Brix
Presence of fiber	Medium
Yield Potential (ton/acre)	12
Distinguished Trait	Fruit bears in clusters



CHENAB GOLD

Time of fruit availability	2nd week of July-2nd week of August
Average weight per fruit	500-700 g
Total soluble solids (TSS)	19-20° Brix
Presence of fiber	Medium
Yield Potential (ton/acre)	12
Distinguished Trait	After harvest of big fruits, small ones attain their size



2.4 Mango Hybrids

With the hectic efforts of the researchers three mango hybrids have been developed and these are getting popularity amongst the mango growers gradually in Punjab.

HASSAN

Time of fruit availability	2nd week of August – 2nd week of October
Average size of mature fruit LxBxT	14-15 x 10-11 x 8-9 cm
Average weight per fruit	350 – 380 grams
Fruit shape in cross section	Broad elliptic
Color of peel	Pale Yellow with light pink tinge
Fruit Skin	Smooth
Pulp Color	Cadmium yellow
Total soluble solids	25 – 26° Brix
Acidity	0.18 – 0.19%
Presence of fiber	Very scanty
Distinguished traits	Late season maturing variety, highly accepted by the local consumers. High yielding culminating better returns for the growers with appealing fruit color giving accent look on the retailer s shelf.



ROHAAN

Time of fruit availability	2nd week of July – 1st week of August
Average size of mature fruit LxBxT	13-14 x 9-10 x 7-8 cm
Average weight per fruit	200 – 250 grams
Fruit shape in cross section	Narrow elliptic
Color of peel	Pale Yellow
Fruit Skin	Smooth
Pulp Color	Cadmium yellow
Total soluble solids	25 – 26° Brix
Acidity	0.18 – 0.19%
Presence of fiber	Very scanty
Distinguished traits	Midseason maturing variety, highly accepted by the local consumers. Taste better than Chaunsa S.B., fiber free having peculiar flavor.



AALISHAN

Time of fruit availability	2nd week of June – 1st week of July
Average size of mature fruit LxBxT	8-10 x 6-8 x 4-7 cm
Average weight per fruit	250 – 270 grams
Fruit shape in cross section	Broad elliptic
Color of peel	Maize yellow
Fruit Skin	Smooth
Pulp Color	Pale yellow
Total soluble solids	22 – 23° Brix
Acidity	0.17 – 0.19%
Presence of fiber	Very low
Distinguished traits	Excellent variety for national as well as international marketing. Highly acceptable by the mango growers due to regular in bearing and consumers due to maximum recovery of pulp without fibers.



2.5 Polyembryonic Varieties

Almost 40 polyembryonic varieties of mango have been imported from Australia to develop homogeneous and true type resistant / tolerant root stock against biotic and a biotic stresses. The preliminary studies revealed that a mango variety 13-1 has tolerance against excessive salts in the soil but it is susceptible to Sodium (Na). On the other hand, Carabao Lamao and Bullock Hearts have been found tolerant against Mango Sudden Death (MSD) while traditional inoculations of *Ceratocystis sp*. were made on the experimental plants. However, further studies for the final screening of these two varieties against MSD are underway.



Carabao Lamao



Bullock Hearts

The following poly embryonic varieties collected from abroad are available at MRS, Shujabad for further studies:

No.	VARIETY	No.	VARIETY	No.	VARIETY	No.	VARIETY
1	Maha 165	9	Carabao Flav	17	Sapa	25	Kasturi
2	Bowen Early	10	Dok Mai	18	Harumains	26	Kensington Pride
3	Bullocks Heart	11	Carabao Super	19	Palmer	27	Falan
4	Brown Seedling	12	Indochinese Late	20	Banana Long	28	Cobera Tongue
5	OK Rong	13	Elephants Tusk	21	Rockdale Siagon	29	Xoai Boui
6	Kamerunga White	14	Pirie	22	Rupee	30	Xoai Cat Hoa Loc
7	Crimson Blush	15	Kuru	23	Pinapple	31	Keaw
8	Carabao Lamao	16	Olour	24	Mullumby Gold	32	Gratidge

3. Soil And Climate

Both soil and climate of a ecosystem are the important factors which determine about success or failure of mango crop.Therefore one should give almost importance to these two factors before establishing a mango orchard.Presently mango is being grown in varied types of soil as well as in different types of climatic conditions across the country.While planning a mango orchard almost importance should be given to take soil sample and its analysis for pH. nutrient status, EC, water soluble salt content etc.Similarly with respect to climatic conditions temperature, rainfall, wind, hailstorms and altitude of the given place should be considered especially in the selection of a variety.Mango grows well on all types of soil provided they are deep and well drained.Alkaline, ill drained and soils with rocky substratum are not suitable for successful cultivation of mango crop.Best quality fruits are produced on soils containing 5 to 10 per cent lime and sufficient quantities of peroxide of iron.Under such conditions fruits develop bright reddish tinge. Generally, the mango growing soils should preferably have a very low total water soluble salt content of 0.04 to 0.05 per cent. The fertility of soil is dependent on its physical, physic chemical and chemical characteristics.

3.1 Physical Characteristics

Some of the important factors included under physical characteristics of soil are the slope or contour of the land, soil type, depth of soil and water table.

- **Slope or contour of the land**
  This is an important factor for successful growth and development of mango crop.The land should be slightly elevated with little slope towards the drain. The drained and basin shaped areas should be avoided because such areas collect more rain water and become water logged. Such situations lead to poor aeration of roots and the roots may turn black and rot, ultimately die. It is a common experience to see that, those trees that are subjected to floods or low lying with poor drainage generally die quickly. Elevated locations are more ideal for mango cultivation. Soils with too much of slope are prone to erosion and too much of drainage and such soils also get moisture depletion quickly and require frequent irrigations.
- **Soil profile**
  Normally the soil profile is studied from top to a depth of 1.8 m or more. It is a pre-requisite for assessing the suitability of the soil of any crop. The depth, texture, structure and others are also considered.
- **Depth of the soil**
  Mango has very deep and strong root system thus soils for mango should be quite deep for easy penetration and spread of the root system. Soils with a depth of 1.2 m or more are ideal for mango crop. More the depth of soil, better is the suitability. Hard soils, soils poor in depth or soils having hard pan in sub-soil should be avoided.

The deep and well drained soils with no impervious layers, allow good depth and distribution of root system producing trees of standard size, heavy yields and long life.

- **Texture**
  The most desirable soil for mango is one of medium texture, deep and well-drained. Sandy soils are poor in organic matter content and other plant nutrients, as such they need to be supplied by heavy F.Y.M. Such soils do not provide good anchorage to root system. Sandy or gravelly soils have poor water holding capacity. While growing mango in such soils, texture of soil should be improved by periodical application of organic manures like farm yard manure or compost.
- **Structure**
  It refers to arrangement of soil particles. The structure of the soil in different horizons should be open, granular and compact structure should be avoided. The sub-soil should be friable. They should not be impenetrable pans such as clay, kankar and rocky. The presence of a substratum of loose gravel helps in providing good drainage.
- **Root penetration**
  It is also a measure of soil aeration. The top 1 m soil should at least permit the penetration of most roots of plants in plenty. Poor drainage is reflected by the poor growth, sickly appearance or death of plants. Mango being a hardy crop, its roots penetrate easily into hard soils like laterite soil and the plant grows luxuriantly.
- **Water table**
  A constant water table is more preferred for good growth and development of mango crop. During any part of the year water table should remain constant and should never fluctuate. For mango the water table should always be at a depth of 1.80 to 2.40 m. If water table is too high then feeder roots will be submerged with water for a long time leading to chloratic patches on leaves. Though the plant may not die but remain unhealthy and growth of the plant is adversely affected.

3.2 Chemical Characteristics

The chemical characteristics include nutrient status, soil reaction and salt content of soil.

- **Nutrient status**
  Surely, nutrient uptake by mango differs with the variety, age of the plant, soil type and management. In general, a crop producing 15 t/ha removes 100 kg N, 25 kg P2O5 and 100 kg K2O. A definite correlation exists between nitrogen, phosphorus, potassium and calcium status of soils and yield of mango.
- **Soil reaction**
  The soil reaction or the soil pH affects the growth of mango trees to a certain extent. Highly calcareous soils having large quantities of lime nodules are considered poor for mango cultivation.

The presence of small amounts of kankar in neutral or slightly alkaline soils up to pH of 7.5 may not harm the tree. A range of 5.5 to 7.5 is ideal for mango growing.

3.3 Climate

Mango is grown in both tropical and sub-tropical conditions. It can tolerate a wide range of climatic conditions. In addition to altitude, temperature, rainfall and the wind velocity also influence growth and production of mango. Mango thrives well under humid and dry conditions. It requires good rainfall during its growing season i.e. June to October and rainless, dry weather from November onwards. Rainy or cloudy weather during flowering favors the incidence of apical necrosis, blossom blight and powdery mildew.

- **Altitude**

  Altitude of a place is one of the important features of the climate which determines good growth of the crop. The plant grows luxuriantly and yields well from sea level to 1000 m above mean sea level. However, for commercial cultivation of mango crop 600 m altitude is ideal.

  As the altitude of the place increases over and above 1000 m from MSL the growth and productivity of the crop are poor. The altitude has a definite role on the time of mango flowering. It has been observed that an increase in every 12 m altitude, flowering is retarded by four days. Similarly for each degree latitude, south or north of the tropics, flowering is delayed by four days.

- **Temperature**

  Climatic conditions particularly temperature, also govern the flowering fruit setting and ripening of fruits. Mango starts flowering early in R.Y. Khan due to onset of high temperature early in the season. Fruit ripening is also earlier in this region than in rest of mango region of Punjab. The annual mean temperature at which mango thrives best is around 27°C.The optimum growth temperature for mango is 24°C - 27°C.

- **Rainfall**

  Quantum of the rainfall is not so important but timing of rainfall has paramount importance in mango region. One of the pre-requisites for successful growing of mango is the absence of rain during the flowering time. Rain at flowering not only washes away the pollens, which adversely affects fruit set, but also encourages greater incidence of mango hoppers, mealy bugs and diseases like apical necrosis, anthracnose (blossom blight) and powdery mildew etc. which damage the crop sometimes completely.

  This also interferes with the activity of pollinating insects, thus adversely affecting fruit set. Excessive rainfall and high humidity even during the time of fruit maturity may result in poor mango crop due to the attack of fruit fly and anthracnose.

  If high temperature, rainfall and humidity persist throughout the year, there will be no distinct phases of vegetative growth and flowering in the mango tree and bearing will be poor as often occurs in Sindh areas.

4. Mango Propagation

The mango, like other tropical and subtropical fruit trees is propagated by several methods, which can be grouped under two main heads, sexual and asexual methods.
In the sexual method, seed raises the plants. Mango is cross-pollinated and heterozygous and propagation by seed leads to enormous variability in the progenies. Therefore, asexual or vegetative methods are adopted to get true to type plants. The technique of grafting in mango had been practiced since ancient times. Now various methods of grafting, budding, air layering and cutting etc. are being adopted with varying degree of success in different mango regions of Pakistan. Almost all the mango varieties are monoembryonic in nature and monoembryonic cultivation should be propagated through asexual methods of propagation. The successful asexual methods of mango propagation are hereby described.

- **Side-Grafting**



It is also known as T method and very popular and commonly practiced. It is exactly similar to that of veneer grafting except that in veneer grafting the vertical flap of the root stock bark is completely removed whereas in side grafting this flap is retained and tied over scion. Another difference between two methods is that only one side of the scion is sliced away in sloping manner in veneer grafting, whereas in side grafting the scion is sliced on both sides of the lower portion in the form of wedge.

- **Wedge Grafting**



Primarily this technique is adopted for rejuvenation of old orchards by top working the trees. The rootstock due to more thickness which is not fit for other grafting technique is used in this method for grafting. The scion selection is similar and procured similarly. The stock is beheaded from any desired height and cut is made at right angle to the main axis of the branch. A vertical split 5.0 to 7.5 cm down the center of the cut stub is made with the help of a sharp knife. The lower end of scion shoot is given two 5.0 to 7.5 cm long slanting smooth cuts on either side. The scion is inserted into split of rootstock, and tied with polyethylene strip. Now this technique is being used very successfully in the preparation of clean mango nursery plants as well.

4.1 Clean Nursery Production

Raising of mango nursery plants under mango trees, is a common practice. In this traditional approach, mango nursery is oftentimes infected by various harms like soil, air, water borne diseases and mango insect pests. Moreover, nursery plants also compete with mango trees to fulfill nutrition and water needs. Now the concept of modern clean mango nursery is getting popularity amongst nurserymen and mango growers to produce clean and containerized mango nursery plants under the technical guidelines provided by Mango Research Institute, Multan.

4.1.1 Site & Infrastructure

- Nursery sites should be isolated, at least 200 m away from mango orchard.
- Ideally the nursery site should be free of excessive dust and shade.
- Sufficient space must be available to construct plant houses, unprotected growing areas, work areas (for preparing potting mix, potting-up, grafting).
- Nursery site needs good access for vehicles delivering raw materials and transporting nursery plants to customers.
- It must be developed in East West directions with iron pipes and black net (70% shade). Size may vary according to need.
- Formation of beds and paved paths may be developed inside lath house accordingly.
- Spread of gravels on the surface of beds will help to avoid soil contamination. Modern nursery floors are typically made of concrete, cement or gravel.
- Encourage drainage and prevent rain or irrigation water accumulating on the nursery site by building a level, well-drained site on a slight slope (up to 2%).
- Always make fence or wall around the nursery.
- Avoid wood, which can harbor plant diseases.
- Increase air movement in plant house as much as possible. This may reduce the media temperature in the container.









4.1.2 Tunnel Construction

Tunnel Size(Capacity = **5000** potted plants)

Width = 28 ft
Length = 80 ft
Height = 11 ft

Pipes

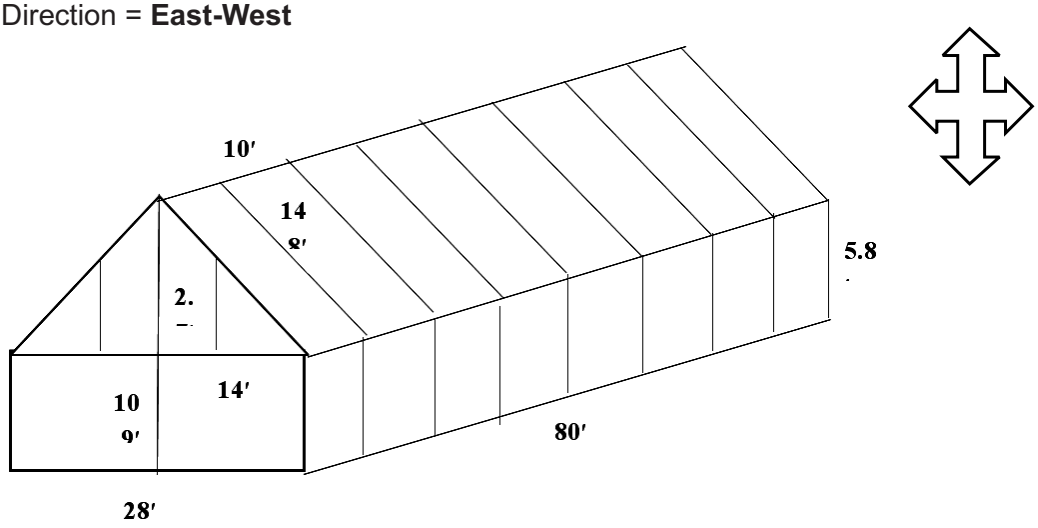
- **G.I. Pipes**

Size = 1.5 inch
Gauge = 12-14
Joints = 1.25 inch
Nut bolts = 2-2.5 inch

Measurements

Size	Number of Pipes
14 ft. 8 inch	18
6 ft. 8 inch	18
12 ft.	9
14 ft.	4
2 ft. 7 inch	4
10 ft.	24

Tunnel Direction = **East-West**



4.1.3 Pot Media

Pot media for clean mango nursery is very important. Using a clean, soil-less potting mix free from disease microorganisms will reduce the risk of disease contamination. Potting mix must have essential media qualities e.g. Air spaces, coherence, organic matter, compressibility, water holding capacity, nutrients retention and lightweight.

Chemical and physical properties of pot media are mentioned below:

- pH = 6.5-7.5
- EC = 900-1600µs/cm
- Water Holding Capacity (WHC) = 35-40%
- Air Filled Porosity = 10-15%
- Media Life = 1.5-2 Years



Sugarcane Bagasse



Coconut Coir

Ingredients

Pot media (standardized by MRI) is comprised of 3 ingredients:

- Sugarcane Bagasse = 65%
- Silt = 30%
- Coconut Coir = 5%



Silt

Media Treatment

It is preferred to treat media after mixing of ingredients. Steam sterilizers are being used on commercial scale, however It may be pasteurized through solarization with covering of polythene sheet to reduce the population of pathogens.

4.1.4 Polythene Bags



Nursery must be sown in clean pots/containers. Growing nursery plants in containers/pots will reduce spread of disease and water need. It is more easy to manage during handling like transport and transplanting. Pots with better drainage capacity will help to minimize the root problems like root rot. Pots must be light in weight and easy to handle. Normally pots of following size are being used in clean mango nursery:

8'x12'

8'x14'

8'x16'

10'x18'

10'x20'

4.1.8 Irrigation

Timely and sufficient water is the most important component for nursery plants, however to produce healthy mango nursery, irrigation water must be fit. Nursery site should have access to a reliable source of high quality water. Saline water will cause several harms for young plants like salt injury. There is no specific time period for irrigation intervals but it is always done according to need by keeping in view the environmental factors like severity of weather. Over-irrigation & less irrigation, both are harmful for healthy plants production, so it is very important to keep in view the irrigation needs of young plants. Used water must be drained out from nursery plants to prevent contamination. Prevent stored water from being contaminated by pests and diseases.

4.1.9 Nutrition

Young nursery plants require macro as well as micro-nutrients to avoid any deficiency symptoms. Nutrition included N:P:K and some essential micro-nutrients are favourable for healthy growth. Various bio-stimulants including Zn, Fe, B, Ca and Mn can be used to fulfil micro-nutrients requirements. Nutrients can be applied in soluble form directly in pots as well as in spray form.

4.1.10 Capacity Building of Nursery Men

- Training of nursery men for nursery operations.
- Divide labour as skilled and un-skilled labour.
- Grafting must be done always by skilled nursery man.

4.1.11 Transporting Plants

- Water the plants thoroughly just before leaving the nursery.
- Shade the plants from excessive sunlight.
- Transport the plants at night during the summer.
- Do not allow plants to dry out during transport.
- Cover the foliage to reduce water loss by transpiration and wind damage.
- Do not allow potting mix to spill out of the pot and expose the roots to dry air.
- Water plants thoroughly on arrival at their destination.

4.1.12 Nursery Inspection & Certification

Nursery inspection and certification is done by Federal Seed Certification and Registration Department (FSC&RD). At least one field inspection of fruits mother plants/scion bank collection and nursery must be made by inspection team of specific concern department (FSC&RD) to see whether the scion to be collected and used are free from graft transmissible diseases mentioned against specific fruit crop. The visit and inspection should be carried out at different management steps especially between May and August for certification of nursery plants and mother plant to be used for propagation in the following year.

4.1.5 Clean Nursery Production

In near past, it has been a common practice to raise mango nursery plants in mango orchards with traditional approach. Now the concepts of modern mango nursery to produce clean & containerized mango nursery plants amongst the nursery men and mango growers are very clear and they have started to adopt this innovation. The major steps for clean mango nursery are briefly described.






4.1.6 Development of infrastructure

- It may be developed at isolated place at least 200 m away from mango plantation.
- It is preferably erected in North & South directions with iron pipes and black net.
- Its size may be variable having different production capacity according to the need.
- Formation of beds and paved paths may be developed inside the lath house accordingly.
- Spread of gravels on the surface of beds has paramount importance to avoid soil contamination.

4.1.7 Preparation of Pot Media

- The pot media for clean mango nursery is very important. The composition of standardized pot media for mango nursery production is baggas by 65, Silt by 30 and Coconut fiber by 5 percent.
- The chemical and physical properties of the pot media are mentioned below:

pH	=	6.5-7.5
EC	=	900 – 1600 µS/cm
Water Holding Capacity (WHC)	=	35-40%
Air filled porosity (AFP)	=	10 – 15 %

- These properties of medium may be checked at random at least 3 times during its whole life (13 months)
- It is preferred to use already decomposed baggas. However, pot media after mixing the ingredients may be pasteurized through solarization with covering of polyethylene sheet. If sterilization facility is lacking which is always done with steam sterilizer on commercial basis.

5. Establishment of Mango Orchard

Establishment of mango orchard is a long-term investment and trees continue to produce fruit for longer years than many other fruit crops. Thus its planting requires proper planning which includes careful selection of site, provision of gentle slope to facilitate proper irrigation and prompt drainage to avoid harmful effect of water logging during rainy season. Similarly, proper maintenance and care is required for profitable return through high production of quality fruits. Special attention is needed in selection of site, field preparation, actual layout of the orchard, proper spacing, digging of pits, selection of planting material and planting, handling of young plants and intercultural operations.

5.1 Site Selection

- Selection of suitable site is the first step for a mango orchard on commercial scale.
- The land which is chosen for mango orchard, planting should be near to main road and market.
- It should have proper irrigation facilities and have a good soil and climate suitable for growth and production of mango trees.
- Any mistake in selection of site cannot be altered after planting while modifications in other factors are possible.Therefore, selection of site should receive the primary consideration.

5.2 Field Preparation and Layout

- Selected fields should be deeply ploughed followed by harrowing to root out the perennial weeds and heavy clods. This operation provides congenial tilth to young roots for their healthy development.
- Proper leveling of land follows this and a gentle slope is provided in one direction to facilitate irrigation as well as drainage of excess water during rains.
- The soils which have drainage problems, should be provided with adequate trenching from the very beginning to avoid serious damage to young plants due to water stagnation.
- After the proper field preparation one should move for layout.
- Proper layout of an orchard is necessary.
- Like selection of site, any mistake committed in beginning cannot be rectified later on.Therefore very careful pre-planning is essential before the actual layout in the field.
- The system of layout to be adopted is decided according to needs.
- The main systems of layout usually in vogue are I) Square ii) rectangular iii) Quincunx iv) Hexagonal

5.3 Traditional System

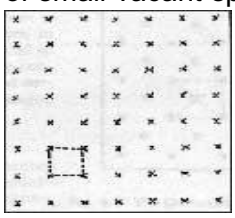
This is old system and has been adopting by the mango growers from several decades. In this system when mango growers had not the idea of pruning in fruit trees and treated the mango trees as forest trees plant to plant and row to row distances are almost 40 or 35 feet with lot of no of 27 plants in one acre.

5.4 Modern System

Now the mango growers are fully conversant about the benefits of pruning in mango tree and the modern system with total of 73 mango plants in one acre is being recommended keeping plant to plant 20 or 22 feet and row to row. 27 or 30 feet for almost all the commercial varieties of mango.

Square System

This system is most common for planting of mango orchards.In this system, the distance from plant to plant and row to row remains the same.The four adjacent plants of two rows form a square.It is easy to layout and permits cross cultivation.The only defect in this system is presence of small vacant space in the center till the plants grow up sufficiently.

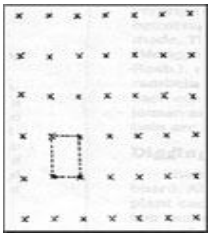


- For actual layout in the field, one boundary line is chosen and along with this line a base line is fixed.
- Then first line is made at the half of the proposed distance parallel to the base line.
- Constructing a right angle triangle in a ratio of 3:4:5 draws a second line.
- The lines of trees are drawn perpendicular to the base line.
- It is so fixed that the lines meeting it are parallel to the field.
- Now the position of trees on base line is marked with pegs.
- From these pegs perpendicular lines, should be marked with the help of cross bars.
- The plant positions can best be marked on all the four sides and finally in the field by running strings length andbreadth wise and by putting pegs at the crosses.

Rectangle System

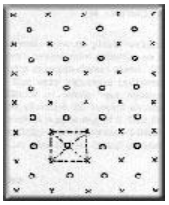
This system is a modification of square system.It is adopted for planting of those fruit trees which require less distance between plant to plant than row to row distance.It has almost all the advantages of square system but cultivation between plant to plant is difficult.

- In field condition it is drawn in similar fashion as the square system except that the distance between plant to plant is less than row to row.



Quincunx or Diagonal System

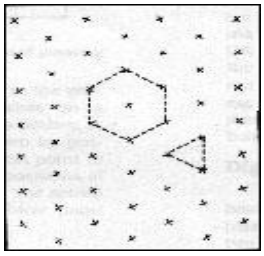
This system of planting is exactly similar to the square system except that an additional sapling is planted at the center of square at intersecting point of the diagonals of the square formed by four adjacent plants.This system accommodates about 10% more plants than the square.The additional plant at center is temporary and termed as filler.The fillers are precocious and short-lived.



- They yield some crop before the permanent trees come into bearing.
- The fillers make cross cultivation difficult.
- Many times the grower often delays their removal and this adversely affects the performance of permanent plantation.

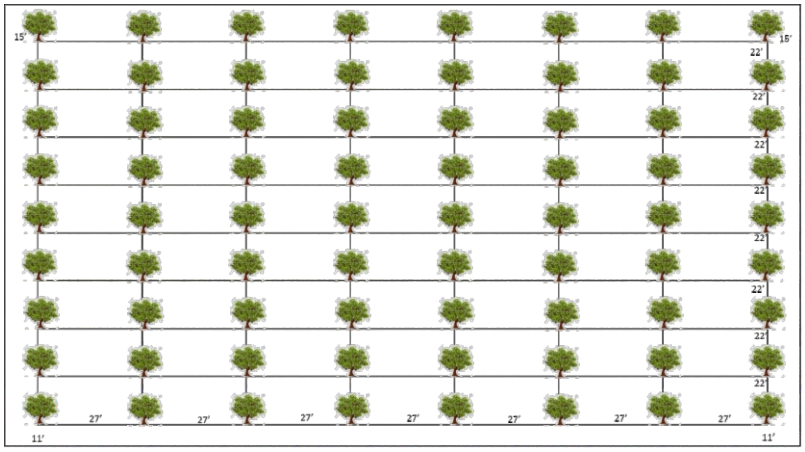
Triangular or Hexagonal System

This system is based on the principle of equilateral triangle.This layout accommodates approximately 15 per cent more trees per unit area than the square system.It is adopted with the advantage where the maximum use of the land is desired, especially on fertile soils.The cultural operations can be done in three directions in the mango orchards laid out on this system.



- For actual layout under this system in the field, a base line is fixed in the same way as done in square system.
- The pegs of the first row are fixed on it at the proposed distance.
- While making the second row, the first peg on it is so adjusted that it is equidistant from the two pegs of the previous row.
- After adjusting two such pegs, a straight line is drawn through these and other pegs are fixed at the proposed distance along it.
- When second row is complete, the third row is drawn in similar fashion as previous one and so on.
- Six adjacent plants base are connected which form a hexagon and seventh plant is in center of the hexagon.

Model Layout Plan for One Acre of Mango



5.5 Planting Distance

- The main purpose of planning of layout of an orchard is to provide adequate space to the plant for normal development to permit proper intercultural operation and easy passage of air and sunlight for the maintenance or orchard sanitation.
- The planting distance depends on various factors like nature of soil, type of plant weather grafted or seedling and variety.
- In poor soils plants make slow growth, so require less space while in heavy soils growth of plants remain dwarf sized.
- Planting distance depends on vigor of the cultivar.
- The very vigorous & semi vigorous cultivars are planted at medium density 20 x 30 or 22 x 27.
- High density planting in mango is not recommended.

5.6 Wind Breaks

- Before planting of mango orchard, it is essential to reserve some place for planting of wind breaks at the border sides of orchard from which hot and high winds and frost are expected.
- Windbreak trees are commonly tall having dense foliage and keep the surrounding atmosphere humid.
- These trees help in minimizing the wind velocity, low or high temperatures which affect adversely the young plants and immature fall of the fruits.
- Now a days the recommendation of polyethylene sheet as wind break in place of trees are being made.
- The trees, which are generally used as windbreak, are seedling mango, Sheshum (*Dalbergia sissoo*), Mulberry (*Morus alba*), Jamam (*Syzygium cumini)*.
- These trees are usually planted close to each other to provide an effective shield.

5.7 Digging and Filling of Pits

- Before digging the pits, two outer pegs are fixed with the help of planting board.
- Already fixed peg is kept in the central notch to mark the right point to plant each tree.
- During digging of actual pit, the central peg is removed and two outer pegs remain undisturbed.
- These outer pegs help in locating the point where the plant is to be put in.
- The size of pit depends on type of soil.
- If there is mild hard pan and stone layer or hard pan within half a meter depth.The pit size would be 5x5x5 feet dimension.
- When the soil is fertile and does not have any type of hard or mild hard pan, the size of pits may be of 2.5x2.5x2.5 feet in dimension.
- When the soil is taken out of the pit, the soil from upper half is kept on one side and from lower half on other side.
- This soil is allowed to weather for 2-4 weeks during summer months so that any type of infection in soil may be destroyed by sunlight.
- Before filling the pit, a mixture of well - decomposed FYM (50 kg), superphosphate (100 g) and Sulphate of potash (100 g) is prepared and mixed with upper as well as lower soil of the pit.
- The mixture of upper soil is filled first followed by lower soil mixture.
- During filling of pits soil is pressed well so that there is no air pocket inside the pit.
- The upper level of pit is kept 15cm above from the field level.
- After filling, the pits are irrigated to settle down the soil of the pit.
- The purpose of digging and filling the pit is to provide congenial conditions for plant growth and development, specially to young plants.

5.8 Time of Planting

- Mango planting is done during rainy season (July to August) and spring season (February to March) in Punjab.
- The spring season is short and followed by a hot dry period of low humidity and hence of mortality of young plants is observed in the field.In Punjab the main season is from July to October.
- The planting is done in evening when the high humidity prevails in the atmosphere, while planting, one should be careful that a polyethylene bag should be removed and the graft union remains well above the ground level.
- The plants should be irrigated just after planting.
- During first week of planting one should rectify the defects like sinking of soil and leveling of plants etc.

5.9 Selection of Grafts for Planting

- Mango grafts of desired cultivar are procured from genuine sources as in the long run the performance of the orchard depends on the quality of the plants particularly

on the pedigree of the tree, their health and vigor. Normally, sturdy grafts with smooth union having equal thickness of rootstock and scion give good performance in the field and such type of grafts are preferred over weak one.

- Six-month to one year old grafts having upright scion growth with 3-4 scion branches are desirable for planting as compared to scion having too many branches.
- Grafts should be purchased from the place having similar soil and climatic conditions that are almost identical with those of the place where the orchard is to be planted.
- Only those grafts should be procured which have been already shifted in the nursery bed to avoid the mortality in the field.

5.10 Planting of Grafts

- At the time of planting, a slightly bigger hole than the size of earth ball is dug at the already marked point.
- The wrapping material is removed from the ball and unwrapped earth ball is put in the hole in such a manner that the plant remains straight and collar portion of plant is kept in the level or slightly higher than the ground level.
- After placing the plant in the hole, the soil taken out from hole previously is pressed firmly around it so that the plant is set firmly in the field.
- During pressing of soil, the earth ball should not be broken.
- Immediately after planting irrigation is done, the frequency of irrigation depends on the weather.
- Regular checking of plants is essential to detect the faults like sinking of soil, tilting of plant and cracking in basin of plant after planting the grafts.
- Sufficient moisture should be maintained till the plants do not set or start new growth in the field.

5.11 Protection of Young Plants

- It is necessary to provide support to the plant by staking in the areas where high winds are more prevalent.
- The staking is helpful to keep plant stem straight and save the plant from damage by breaking from graft union.
- The young plants are more prone to frost damage during winter months.
- The most common method to save the plants from frost is to thatch them.
- The thatching can be of any type of dried grasses or of polyethylene sheet.
- The plants are covered on all sides except North-West and South-East so that the sunlight may enter in morning and evening times.
- This thatching material is used in winter months and may also be used in summer months against the hot winds.
- During these months frequent irrigation (at 7days interval) is essential to save plants from desiccating winds and regular weeding of plant basin is required to eradicate weeds.
- Bio-fencing is done on sides of orchard to save the young orchard from cattle and wild animals.

5.12 Early De-blossoming

- Young mango plants prepared through asexual methods of propagation start flowering immediately after the year of planting or even at the nursery stage.
- This adversely affects the growth and vigor particularly when such types of plants are allowed to set fruits.
- This fruiting is one the expense of growth and hinder the formation of strong framework of the plant.
- Therefore, these inflorescences should be nipped off immediately after emergence so that it may not disturb vegetative growth.
- The de-blossoming should continue till the plant attains five years age.
- By this time plant attains normal size and it is physiologically sound to bear the fruits.

5.13 Inter-culture and Intercrops

- Good sanitary condition is a must for keeping an orchard healthy and disease free.
- For proper growth of young plants timely hoeing and weeding is essential and plants should always receive priority over other considerations.
- Orchards should not be kept in neglected condition in pre-bearing stage by paying more attention to the intercrops.
- Such neglected orchards prove costly as fruiting is delayed and longevity and productivity are reduced.
- Clean cultivation throughout the year is not desirable in mango plantation.
- Therefore, vacant space between the trees is utilized for growing intercrops such as vegetables and legumes to earn extra income from the mango orchard.
- The vegetable crops, which may be grown in mango orchard, are onion, tomato, radish, carrot, beans, cauliflower, cabbage and palak.
- Generally the intercrop should be planted well away from the mango plants and these should not compete for nutrition and moisture.
- The nutrition and moisture to intercrops must be provided in additional amount.
- The intercrops should to be taken in initial stage of orchard establishment when there is no income from the primary crop and should continue till the main crop plants come in full bearing. By growing intercrop, the weeds are kept in control which lead to depletion of nutrients and become host for diseases and insects.
- Press the soil firmly around it so that the plant is set firmly in the field.
- During pressing of soil, the earth ball should not be broken.
- Immediately after planting irrigation is done, the frequency of irrigation depends on the weather.
- Regular checking of plants is essential to detect the faults like sinking of soil, tilting of plant and cracking in basin of plant after planting the grafts.
- Sufficient moisture should be maintained till the plants do not set or start new growth in the field.

6. Care of The Orchard After Plantation

- For the successful establishment of a mango orchard. it is necessary to protect the newly planted sapling from excessive heat, moisture and cold.
- Winter is severe in Punjab and plants must be protected from frost. For this they are thatched with any type of dried grass or paddy straw.
- The plant is covered from 3 sides. leaving a gap towards south to allow entrance of sunlight and air.
- Likewise it must be protected in summer to avoid scorching from hot winds and intense heat of the summer months.
- During these months, timely irrigation is very necessary .
- The frequency of irrigation for young plants ought to be at least once a week.
- Care should be taken to remove the weed.
- If any as they compete with the plant for moisture and nutrients.
- During rainy season, water must not be allowed to stagnate around the plant. as it will affect the root activity adversely.
- For this a perfect drainage must be maintained in the orchard.
- When mango grafts have grown taller, the stem may be whitewashed with lime to protect from sunscald.
- The young grafted plants of mango may start giving inflorescences even after a year of planting.
- If these are allowed to bear fruit growth of the plant is adversely affected.
- Therefore such inflorescences should be nipped off immediately after their emergence, so that the vegetative growth is not hindered. This practice should continue till the trees complete 4 years.
- By this time the plants will have formed a definite framework.
- After satisfactory completion of the juvenile phase. trees could be allowed to commence bearing.
- For a proper framework. it may be advisable not to allow branches at the base of the main stem to trail on the ground. Such branches should be removed in the early stages of growth. to leave a standard main trunk without any branch up to a height of 1 m.
- Main scaffold branches along with the leader should be allowed to develop at this height.
- This will facilitate cultural operations in a mango grove.

6.1 Intercrops and Cover Crops

- As mango 'trees take longer time to yield any profit to the grower. it is desirable to supplement one's income by growing some short-term crops till they are shaded by the trees. Such crops when taken in the orchard are called intercrops.
- There is another kind of cropping in the orchard when the orchard soil is covered with some crop which in due course is turned back to the soil to supplement organic matter of the orchard soil.This is called cover crop.

6.2 Principles of Intercropping

- Intercrops should occupy a secondary place in the orchard, primary consideration being given to the perennial fruit trees.
- The crops that may grow tall and have a tendency towards excessive growth should be discouraged.
- At least 120cm (4 feet) radius must be left from the base of the growing fruit trees for taking intercrops.
- Water requirements of the intercrops should as far as possible coincide with the requirement of fruit trees.
- Such intercrops should be selected that do not exhaust the nutrients and moisture from the soil, so essential for the growth of fruit trees.
- Perennial or exhaustive crops should be discouraged as an intercrop in the orchard.
- This may have devitalizing effect on the growing trees.
- For example, sugarcane, maize, jawar should invariably be excluded from an intercropping program in the orchard.

6.3 Different Intercrops

- Vegetables that have their roots within 25cm depth of the soil are considered good for intercropping.
- These are tomato, onion, cauliflower, beans, palak etc.
- These vegetables can be taken profitably in a growing orchard by appropriate application of nutrients to the soil and also maintaining an optimum level of moisture.
- Among the annual crops, due consideration should be given to the legumes such as pea, lentil, blackgram and greengram.

6.4 Fruit Crops as Intercrops

- While taking some of the short-term and early bearing fruit crops as an intercrop, due consideration is essential in the selection of a particular fruit.
- This is essential because the roots of such trees may start competing with the roots of main fruit trees for nutrients and moisture.
- The filler trees, unless removed at appropriate time when primary fruit trees start giving economic crop, may create problems of low orchard efficiency.
- Keeping this point in mind, it is apparent that strawberry can be grown, it may serve as an ideal intercrop.
- Falsa could also be included in the early stages of growth of the trees, provided these are maintained properly by adequate pruning and removal at proper time.

6.5 Cover Crops

- These save the orchard soil from being eroded during the rainy season, particularly in areas where drainage is not proper.
- When the cover crops are turned into the soil, the organic matter of the soil is increased, and this results in many advantages.
- For example, if organic manure such as compost or farmyard manure is not available, the nutrient requirements of fruit trees can be met by applying only artificial fertilizers without any adverse effect on the soil.

- Water-holding capacity of the soil is increased and the biological complex of the soil is also improved.
- It is preferable to take leguminous crops for cover cropping so that nitrogen fixation in the orchard soil is facilitated.
- Another advantage of cover crops is that they will prevent the growth of weeds.
- During rainy season (Kharif) greengram, blackgram, cowpea and guar are preferable.
- During winter season (Rabi) it is desirable to take pea or lentil etc.
- The most important point in the selection of cover crops is the requirement of water of a particular crop.
- If a particular crop needs to be irrigated very frequently when the orchard trees are not in need of moisture, this will certainly tell upon the productivity of the fruit trees.
- For example, if berseem is taken in a mango orchard during winter when fruit-bud differentiation and flowering is expected and the orchard is irrigated too frequently, it may not be conducive to the productivity of the tree in general.
- Crops which are cultivated during rabi and which require regular and good amount of irrigation should not be preferred.
- The reason is that the fruit-bud differentiation of mango under subtropical conditions takes place in November- December, and irrigation during this period or before will interfere with the fruit-bud differentiation and affect ultimately the production.
  In this group of intercrops are included crops like berseem and wheat, which have to be avoided.
- Also, with growing of berseem in between the tree rows, the nitrogen status of the soil rises, which encourages good vegetative growth at the cost of fruit quality.
- Another groups of crops which need to be avoided as intercrops are those which are grown for seed/grain.
- In this are included wheat, oats, gram, oilseeds, pea and radish (for seed).
- The reason is that the period of seed formation and subsequent development of seed in the intercrop generally coincides with the period of active fruit development in mango, and during this period the intercrops extract maximum amount of moisture and nutrition from the soil and deplete it, irrespective of the care taken to replenish it for fruit trees.
- Similarly, certain crops such as Cotton, Maze and Jawar are basically heavy feeders and extract maximum amount of nutrients from the soil for several months during which these crops stand in the field. Such crops should therefore be avoided.

6.6 Growing Intercrop in an Orchard

- The method of growing intercrop in an orchard is different in the young and the bearing orchards.
- In the former the entire land is utilized, leaving only the basin portion of the tree.
- The tree is located in the middle of the bed in which the crop is grown.
- As the trees grow in age, the size of the basin increases and the area for intercrops gets reduced gradually.

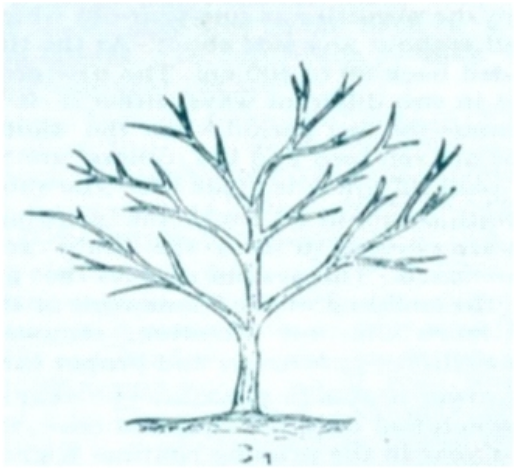
- When the trees attain good bearing age, the intercrop is grown in between the tree rows in 1 direction, i.e. on 2 opposite sides of the trees, leaving the other 2 sides open.
- The tree rows are enclosed by a strong bund on 2 sides running from one end of the orchard to the- other.
- This facilitates irrigation of trees within the bundled space independently of the intercrop.
- It also provides space for movement during plant protection and other operations in the orchard.
- While taking intercrop, a common mistake is to leave the fruit trees to obtain nutrients from the same fertilizer dose applied to the intercrops.
- This is one of the main causes of orchard decline in most parts of the country .
- The intercrop and the fruit trees must receive separately their independent requirements of fertilizer and irrigation.
- Besides, intercropping in orchard promotes infestation of pests and diseases in greater intensity than under clean cultivation.
- This is due to increase in the humidity and vegetation around the trees due to intercrops.
- Hence regular plant-protection measures against pests and diseases of the mango crop are essential.
- Cultural schedule and its important factors responsible for the decline of fruit yield and proper fruiting pattern mostly pertain to management practices such as nutrition of trees and control of weeds, insect pests and diseases.
- If the trees do not present a healthy appearance and leaves look somewhat yellowish, it is obvious that such trees suffer from under-nutrition.
- If the cover crops or intercrops are taken regularly, the weeds will be automatically suppressed.
- A constant watch over the diseases and insect pests of mango is necessary for ensuring quality crop from the trees.
- When the humidity builds up appreciably during the flowering time, incidence of anthracnose is very much increased, and sometimes this may result in blossom blight and no fruit set.
- One of the important schedules in mango orchard management is maintenance of excellent sanitary conditions in the orchard and regular pruning of the malformed parts (both vegetative and floral) in the tree, if any. This will ensure reduced incidence of mango malformation.
- Proper irrigation of trees, particularly during summer, is very essential to get quality crop from the bearing trees and proper growth in young plants.
- While bearing trees ought to be irrigation at an interval of a fortnight during summer, younger plants need weekly irrigation.
- Trees must be regularly observed for any setback due to any cause and steps must be taken immediately to remedy it.

- A proper round-the- year cultural schedule must be drawn up before hand and operations should be done as per schedule.
- This will ensure production of quality crop from healthy mango trees.

6.7 Training and Pruning

- Mango being and evergreen plant requires very little training and pruning.
- Training of young plant is done in early years of planting by removing side branches up to the height of one meter from the ground level and side branches are allowed to grow beyond 1 meter height.
- Such type of initial training provides good architecture of the plant and it is helpful in good fruit production.
- Most of the cultivars of mango grow erect, from a natural dome shape canopy and having symmetrical branching need only occasional pruning.
- Generally dead, diseased or crises cross branches are pruned.





7.Irrigation

For mango, a good water supply is very important to ensure good growth and high quality fruit. Too much water can lead to water logging and root rot and too little can stress the tree and stunt growth. In this scientific era now there is some equipment through which requirement of water is monitored e.g. Tensiometer, Soil Moisture Meter and Neutron Probe etc. Sensors of monitoring system are placed in position under drip line of the tree where most of the feeder roots prevail. The position should receive an even water application and soil type should be representative of the block. The watering becomes necessary when the sensor alarms for low moisture level near the root zone. In fruit plants, during each phenological stage the requirement of water is always different. It may vary according to prevailing weather conditions as well. Hence, it is still imperious to conduct a comprehensive study to find out the requirement of mango plant according to its each phenological stage and need of the feeding roots in accordance with the changing environmental and weather conditions.

7.1 Properties of Irrigation Water

The irrigation water must have following chemical properties.

Electrical Conductivity (EC)	=	<1250 µs/cm
Residual Sodium Carbonates (RSC)	=	<1.25
Sodium Absorption Ratio (SAR)	=	<6

7.2 Principles of Irrigation

7.2.1 Irrigation in Relation to Soil and Climate

The irrigation requirements of mango are closely related to soil and climate of the orchard. The fine textured deep and well drained soils generally have the property of retention of water, require less irrigation. Very fine textured and sticky soil requires no irrigation. Other groups of soils like light and medium textured require adequate surface irrigation, provided they are well drained. Any type of soil having water table up to 3 meter from surface requires no water as the roots of mango tree travel to this depth in search of water. Irrigation in mango is also associated with climate including humidity, rainfall and temperature. Mango orchards situated in humid tropics do not require irrigation irrespective of soil type while under dry climate having low humidity and high temperature; irrigation is needed at 15 days interval.

7.2.2 Irrigation in Relation to Root System

Mango tree has deep, well spread and extensive root system in most of the soils. The main root develops secondary roots that go to sub-soil layer. The one set of root system is found in the first 60 to 90 cm of the soil. This extensive type of root system helps the mango tree for its success and in most of the situations only light surface irrigation is sufficient. This extensive root system of mango draws and gets the moisture from far and wide. In some odd conditions, the extensive root system development is checked by hard pan rock, stony layer or the dwarfing rootstock used in grafting. In this situation root zone is kept restricted and ultimately it restricts the vegetative growth of plant. Trees under such situations require more frequent irrigation to get good yield and quality fruits.

7.2.3 Irrigation in Relation to Fruit Bud Differentiation

The carbohydrate accumulation in mango is accompanied by fruit bud differentiation and at this time there is no active growth, so little or no carbohydrate is utilized by plant. Irrigation promotes vegetative growth under favorable climatic conditions. Therefore, it is suggested that during fruit bud differentiation period irrigation of mango bearing plants should be stopped, otherwise irrigation during this period converts fruit/flower bud into vegetative bud which ultimately adversely affects the fruit yield.

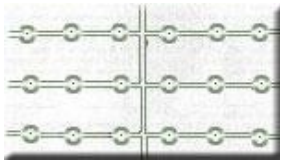
7.2.4 Irrigation in Relation to Fruit Set, Size and Quality

Fruit set in mango does not have any relation to soil moisture unless the soil moisture is deficit for longer period. However, soil moisture influences the fruit size, quality as well as the drop of immature fruits. During fruit development period, under hot and dry climate, the irrigation prevents the drop of immature fruits. The moisture deficit in soil brings early maturity to fruits. So regular and normal irrigation to plants during fruit development and maturity period improves the quality of fruits. The fruits are of better size and more juicy from irrigated plants than those from tree under deficit soil moisture. Therefore, regular and timely irrigation of bearing plants becomes necessary.

7.3 Methods of Irrigation

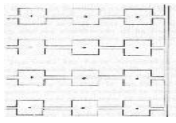
A number of irrigation systems like basin, ring, furrow, flood, sprinkler and drip are employed. Each system has advantages and disadvantages as one system may be suitable for one set of conditions but unsuitable for another. Therefore, proper selection of the irrigation method is important for better orchard management practices.

Basin Method



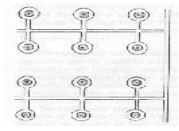
In this system of irrigation, small circular basins are made around the tree trunks. These basins are connected with each other through a straight channel. The water passing through these channels touch the tree trunk directly. Such type of flow from plant to plant may cause damage and manures and fertilizers may be washed away with water and deposited at the end of the channel. The disease present in one plant may spread to other plants. In this way it increases the infection. The effective root zone is not properly irrigated. Therefore, this system is considered as defective one.

Modified Basin System



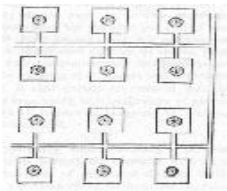
This system is similar to that of basin system except that instead of circular ring, the rectangular shape basin having bigger size is made. This system is also not adopted on large scale.

Ring System



This system is an improvement over previous systems. The irrigation channel is made between two rows of mango trees. Here the basins are kept small having circular shape. The individual basin is connected by sub-channel to the channel formed between two rows. Due to small size of basin, adequate amount of water is not accommodated which is sufficient for plant requirement. It is the disadvantage of the system.

Modified Ring System



This system is exactly similar to that of ring method. The only difference is the size of the ring. Here the ring is made up to the spread of plant canopy, which accommodates sufficient water, required by tree.

Furrow Method of Irrigation

Here the 2-3 furrows are made along the row on both sides. This system is suitable for the places where the flow of water is so regulated that it moves with slow speed. Here the plants are irrigated through lateral movement of water. Although this system is good but not adopted at large scale.

Flood Irrigation

This system is adopted in such orchards where sufficient water is available. Here entire area of orchard is wetted and meets the water requirement of tree and suited best to the extensive root system of mango.

Trickle or Drip System of Irrigation

This system is applied in those orchards where the water is in limited quantity and available water is used more judiciously. Here the irrigation to the mango plants is applied through drippers/emitters connected through micro-tube to the lateral. The laterals are connected to sub-main or main line in which water is supplied through a pumping unit from the source. The young mango plants require 9-12 liter/day/plant water for better growth. The plants of 3-6 years, 6-10 years, 9-12 years and full grown trees require approximately 30-35 liter, 50-60 liter, 80-90 liter and 120 liter/day/plant. This system has several advantages such as plant attains quick growth, water saving, weed sudden death control, labor saving, easy nutrient application and increase in yield of good quality fruits. The only disadvantage is the high initial cost of installation.

7.4 Irrigation in Young and Non-Bearing Orchards

The principal object of irrigation of young and non-bearing orchards is to boost fast and vigorous growth of the plants.

- In initial stage the root spread of the plants is limited.
- Light irrigation at frequent intervals is required to wet the soil.
- The non-bearing trees 4-5 years of age are irrigated at weekly interval.
- The interval of irrigation depends upon tree age, soil and climate.
- For the first six months after planting, interval should be 2 to 6 days, for 6 to 12 months old plant at weekly interval and 7 to 20 days till the plants attain bearing age.
- In light soil irrigation frequency is more than in heavy soils.
- During winter, the irrigation is specially required for protection against frost.
- In heavy soils, frequent irrigation causes damage to root system and stem so it should be avoided.
- But the interval should not be too long so that plant faces moisture stress and the growth and spread is checked.

7.5 Irrigation in Bearing Orchards

- ☐ The irrigation of bearing orchards at regular intervals (10 to 15 days) is prime necessity during fruit set and for full fruit development.
- ☐ It is helpful in attaining full fruit size and reducing fruit drop.
- ☐ But to obtain good flowering, the irrigation during winter months (2-3 months) flower bud differentiation should be stopped.
- ☐ Irrigation during this period promotes vegetative growth, which will be detrimental to flowering.
- ☐ In light soils, the interval of irrigation would be high during hot, dry and windy weather than in cold and calm atmosphere.

7.6 Schedule for Irrigations in Mango Orchards:-

Time period	Phenological cycle	No of irrigation	Status
Mid Feb to March	Flowering and fruit setting	02	if the diurnal temperature rises up to 30°C then interval of irrigation may be decreased
April to July	Fruit development	6-8	To maintain the internal temperature of mango plant to develop mango fruit properly and to stop the fruit drop irrigations are necessary but Stop the irrigation before 15 days of the harvest of the fruits.
August to September	Vegetative growth & their maturity	01	After getting the new flushes after harvest their maturity is needed with judicious irrigation
October to November	Bud Induction	0	Irrigation is withheld to ease the phenomenon of flower bud induction.
December to Mid-February	Dormancy	01	Irrigation is also withheld to promote the flower bud differentiation but during frost expected nights it is recommended.






8. NUTRITION

8.1 Assessment of Nutrients

Soil and leaf analysis is the only tool in hand to assess the requirements of nutrients for mango plants.

8.1.1 Soil Analysis

For soil analysis, the Punjab Government has established laboratories at each district level and analysis has been conducted with very nominal price. Soil samples are collected with the soil augur from the following depths.

1.	1 – 15 cm	4.61 – 90 cm
2.	16 – 30 cm	5.91 – 120 cm
3.	31 – 60 cm	6.121 – 150 cm

All the samples are mixed together to make composite sample 0.5 Kg sample is sufficient for lab analysis as a representative of the soil conditions.

8.1.2 Leaf Analysis

Leaf analysis is the best way to estimate the macro and micro nutrients. Almost 100 mature leaves of 4-6 months of age, are collected from four sides of 20 mango trees during the months of September or October. Out of which a composite sample comprising of 40 – 50 leaves is sufficient for lab analysis.

8.2 Critical Levels of Nutrients in Soil and Leaf

After a series of study, critical levels of macro and micro nutrients in soil and leaf of mango have been standardize as described below:-

Element	Soil	Leaf
N (O.M)	> 1.29 %	1 – 1.2%
P	>15 ppm	0.07 – 0.8%
K	> 250 ppm	1.2 – 1.5%
Zn	1 ppm	25 ppm
Cu	0.2 ppm	7 ppm
Fe	10 ppm	150 ppm
Mn	1 ppm	20 – 25 ppm
B	1 ppm	20 – 25 ppm

8.3 Kinds of Fertilizers

Generally three types of fertilizers/manurs along with their brief description are mentioned below:-

1. Natural manures
2. Green manures
3. Chemical fertilizers

Natural Manures

Manure	N	P	K	O.M
F.Y.M	0.55	0.25	0.55	22.0
Cattle	0.80	0.40	0.50	35.0
Poultry	1.50	1.00	0.50	40.0

Green Manures

Crop	Sowing Time	Manuring Time	O.M/acre (kg)
Guara	May – June	July	7500
Sun	April – May	July – August	7500
Jantar	March – April	June – July	6500
Senji	Oct – Nov	Jan – Feb	8700

Chemical Fertilizers

Sr#	Fertilizers	Element	Quantity (%)
1.	Urea	N	46
2.	Ammonium Sulphate	N	21
3.	Ammonium Nitrate	N	26
4.	Nitro Phosphate	N+P	23+20
5.	Diammonium Phosphate	N+P	18+46
6.	Single Super Phosphate	P	18
7.	Triple Super Phosphate	P	46
8.	N.P.K (1)	N.P.K	15:15:15
9.	N.P.K (2)	N.P.K	17:17:17
10.	N.P.K (3)	N.P.K	21:21:21
11.	Sulphate of Potash	K2O	50
12.	Muriate of Potash	KCl	60

8.4 Application of Fertilizers

The life cycle of mango may be divided into five stages: the nursery, the establishment in the field, the non-bearing period, the bearing period, and the aging trees.

The nutritional requirements in each of these periods differ.

Speedy growth of root-stock seedlings and proper establishment of grafts are the chief objectives in nursery.

At the time of establishment in the field, it is necessary to ensure least mortality.

The main requirements in the pre-bearing age are rapid growth of the tree and the development of a sound and strong framework.

During the bearing period, good cropping, regular bearing and high quality of fruit are expected.

When the trees are aged, rejuvenation or reinvigoration is desired.

These objectives have to be met by different prescriptions.

8.4.1 Transplanting Stage

It is generally advisable not to apply any manure at the time of planting. Almost all soils selected for planting mangoes have enough nutrients available to support growth of the trees at least for a year.If the soils are too poor to sustain them even over such a short period, they are best not utilized for mango cultivation. Further, the application of manure at the time of transplantation can prove harmful. It may attract white ants.

8.4.2 Non-Bearing Stage

This stage extends from the time the plant gets established in the field. In this period the need for calcium, nitrogen and phosphorus is high. Potassium is also required in reasonable amounts. During the non-bearing period nitrogen is particularly required in sufficient amounts to induce vigorous growth. It would be better if some part of N is derived from organic matter so that soil texture, moisture-holding capacity and ultimately the growth and development of roots improve. Phosphorus would be required to cope with high respiration rates and for translocation of carbohydrates. Potassium would also be required to meet the need of photosynthesis but its need during non-bearing period would be comparatively less than that during the bearing period when it is required for sugar and starch synthesis in greater quantities.

8.4.3 Bearing Stage

The mango is a terminal bearer. The fruit-bud differentiation takes place about at least ninety days before flowering. During the flowering and fruiting, the vegetative growth must be limited which, in turn, affects the fruit quality. The shoots from the flushes after harvest are supposed to be best ones to flower in the next spring. If the mature vegetative shoots are not available at the time of bud differentiation or formation of floral buds, hence, there would be no flowering in the next spring. The manuring of the bearing tree is thus faced with certain complex problems which the grower must keep in mind in order to adjust his practices fruitfully. Thus, the objectives should be:

Securing sufficient vegetative growth after harvest for the next year's cropping, Maintenance of tree vigor, and Improving the quality of fruit.

8.5 Fertilizer Requirements According to Age:-

Plant Age (Year)	Nitrogen (g)	Phosphorus (g)	Potash (g)
2	200	50	50
3	300	100	100
4	400	150	150
5	500	200	200
6	600	250	250
7	700	300	300
8	800	350	350
9	900	400	400
10	1000	500	500
11	1100	600	600
12	1200	700	700
13	1300	800	800
14	1400	900	900
>15	1500	1000	1000
Special Cases	1500-2000	1000-1500	1000-2000

8.6 Fertilizer Recommendation for Early Varieties

TIME SPAN: 15 JUNE TO 15 JULY

Time	Nitrogen (g)	Phosphorus (g)	Potash(g)
After Harvest	1000	1000	500
Before Flowering (February)	500		500

8.7 Fertilizer Recommendation for Mid Varieties

TIME SPAN: 15 JULY TO 15 AUGUST

Time	Nitrogen (g)	Phosphorus (g)	Potash (g)
After Harvest	1000	1000	500
Before Flowering (February)	500		500

8.8 Fertilizer Recommendation for Late Varieties

TIME SPAN: AFTER 15 AUGUST

	Before Flowering	At the time of fruit set
Nitrogen	750	750
Potash	500	500

Phosphorous	1000 g after harvest (or) with FYM in December

8.9 Micronutrients

Micronutrients are required by mango plants in a very low quantity but have paramount importance. These can be applied through soil and foliar sprays. When there is active growth on the mango plants. These may be applied only after observing the deficient symptoms or leaf analysis.

Element	Foliar Spray (g/100 lit)	Soil application (g/plant)
Zn	Zinc Oxide. 200 Zinc sulphate. 150-200	Zinc sulphate 150-200
Mn	Manganese sulphate 200	Manganese sulphate 200
Cu	Copper sulphate 200	Copper sulphate 100-150
B	Boric acid 80	Borax 200
Fe	Ferrous sulphate 200	Ferrous sulphate 100-200

Effects of micronutrients on growth, flowering, fruiting, yield and quality of mango are quite visible.The improvement in fruit quality is attained by zinc sulphate spray.

Progressive increase in the length of terminal shoot, number of leaves and leaf area, length of floral panicle, number of male and hermaphrodite flowers and yield is also observed with the application of zinc sulphate.

Significant effect of boron on the growth, flowering, fruiting and fruit quality may be observed by 0.08 per cent boric acid spray. An increase in fruit size, weight, TSS, ascorbic acid, acidity and sugar content is quite possible by the spray of boric acid and zinc sulphate.

8.10 Nutritional Disorders

8.10.1 Nitrogen

Nitrogen is the most important element for yield & quality of mangoes. It is also a main nutrient affecting growth, flush, flowers, fruit & roots. It improves fruit set, retention and yield, increases fruit size and brix. It is readily translocated in soil & tree readily respond to Nitrogen. The plants can only take up N in the ammonium (NH_4^+) or nitrate (NO_3^-) form. Poor vegetative and reproductive growth, reduction in fruit size, poor yield, increased fruit drop are the main nitrogen deficiency symptoms. Excessive N have negative effects like excessive leaf growth, low K concentration, early fruit set, drained of Ca from fruit to leaves, green, ripe fruit, less blush, softer fruit, increased internal disorders and increased postharvest rots.





8.10.2 Phosphorus

Phosphorus is important for cell division and Involves with the production and movement of energy within the plant. It is also necessary for seed (and therefore fruit) development. It initiates and develops root laterals. It makes possible for the plants to get adequate uptake of other nutrients, very mobile in the plant but not in the soil. Generally, phosphorous is not limiting element in mangos and surely soil pH affects its uptake.



8.10.3 Potassium

Scorching of leaf margins is the characteristic symptom of potassium deficiency. Scorching starts from tip downwards. Fruit quality is reduced. Trees with potassium deficiency are easily prone to pests and diseases attack.

Application of 2 kg sulphate of potash in the basin could rectify potassium deficiency.

Dropped leaves should also be incorporated along with manures to enrich the soil health and fertility.



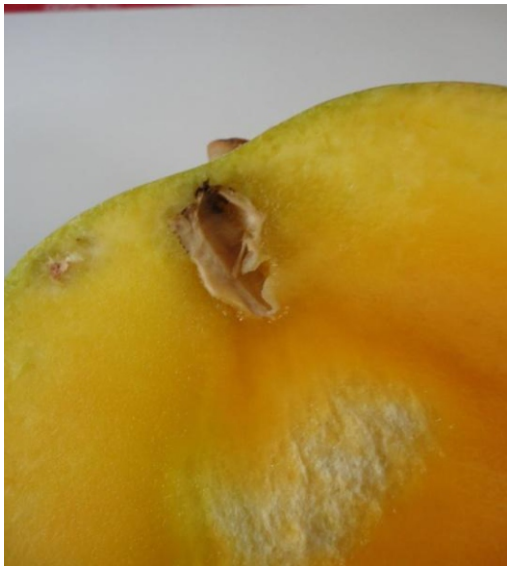


8.10.4 Calcium

It strengthens cell walls, provides defense from pathogens. It is important during cell division and fruit quality (firmness & shelf life) etc. Calcium is not easily translocated in the tree. Its uptake is passive and needs soil moisture. It is difficult to get in to fruit from soil or leaf and its foliar applications of little use. Its uptake speed depends on particle size.









8.10.5 Zinc

Due to zinc deficiency the leaves become small and narrow with leaf margins bent upward or downward. Internodal length is reduced drastically and the twig with crowded leaves gives rosette appearance. Pale intervenial areas and green veins are typical of zinc deficient leaves. The tree with zinc hunger does not grow well and the yield, size and quality of the fruit are reduced. Small plants with severe zinc deficiency may die.
Zinc deficiency is conspicuously seen in alkaline and saline soils.
Spray of Zn based fungicides especially during flowering season may cope with the task as well.



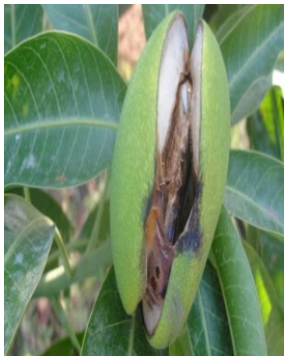


8.10.6 Boron

Boron toxicity usually on older leaves causing leaves to have brown edges and distinctive scalloped pattern. Lusterless leather leaves with thickened veins are the other associated symptoms. In boron deficiency case, leaves can have a short hole, affect and the symptoms can be confused with anthracnose. Further, cracking of fruit is the characteristic symptom of boron deficiency and brown area in yellow fruit pulp is always conspicuous.
Application of boric acid @ 80-100 g per 100 lit of water during fruit setting dose not only rectify boron deficiency but makes the better fruit setting.







8.10.7 Iron

The leaves lose green colour and turn white and is called "Bleaching". The size of the leaf is reduced. In severe cases of iron deficiency, the leaves dry from tip downwards. The deficiency is common in soils with high calcium content. Hence, the effect is known as "calcium induced iron chlorosis". The growth of the tree is restricted; yield and quality of the fruit are reduced. Small plants may die due to acute iron deficiency.

Two sprays at fifteen days interval with ferrous sulphate 2.5 g per liter of water effectively check iron deficiency when the symptoms are observed.





8.10.8 Salt Injury

The dying back of the leaf tip and areas adjacent to the center of the leaf exhibits an irregular area of dead brown and dry tissue which may sometimes involve maximum one half of the area. Such an area is subsequently attacked by fungi. The cause of the tip burn us not known but salt sprays and salt in the water used for overhead irrigation causes one form of tip burn. Other factors viz., deficiency of moisture due to drought, high contents of salts in the soil and damage to root systems have been considered the contributing factors.

FYM should be applied every year in the orchard. Application of Gypsum around the basing of the mango tree is advocated after soil analysis.



